NASA TECH BRIEF

Magnetic Forming Studies

The use of transient high magnetic-field devices has made possible the generation of very large accurately known stresses in metals. A basic problem in calculating with some precision the deformation resulting in a metal workpiece by the application of any given force profile is the lack of data on the effective tensile strength and its dependence on the pressure pulse time. Performance tests conducted on a variety of magnetic hammer configurations markedly demonstrated that the deformation of workpieces increases much more rapidly with the duration of the pressure pulse than can be explained by a theory based on a unique, time-independent tensile strength. The plausible inference is that the tensile strength depends on the characteristic time over which the pressure pulse is applied to the metal. A series of basic experiments was conducted to investigate in detail this inference.

These investigations cover two distinct configurations. In the first geometry, the samples are straight wires which are stressed uniaxially by magnetically accelerated anvils. In the second geometry, the samples are wire hoops which are stressed radially outward by a transiently induced Lorentz force. The first experiment is aimed at measuring stress–strain relationship in a way analogous to the classical Hooke method. The difference is that the new approach is based on elastodynamics rather than elastostatics. In the second experiment the objective is to define the elastodynamic behavior of materials which are stressed by purely electromagnetic forces as contrasted to the mechanical forces used in the first geometry.

The materials tested in the experiments include copper, aluminum alloys 1199-H14, EC-0, 5056-H38, 6061-0, 6061-T6, 2319, and a carbon steel. The results show that the mechanical properties (dynamic yield strength and ultimate tensile strength) of these materials are functions of the rate at which the material is undergoing strain. These results and analytical techniques applied in the investigation are of immediate usefulness in magnetomotive metal forming and are also generally applicable to a number of pertinent situations encountered in other high energy-rate forming methods.

Notes:

1. A magnetic (magnetomotive) hammer developed for removing weld distortions from aluminum alloy tanks is described in Tech Brief 65-10342.
2. Complete details concerning this investigation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B68-10186

Patent status:

No patent action is contemplated by NASA.

Source: R. W. Waniek, H. P. Furth, P. J. Jatmuz, R. C. Mehra, D. R. Holt, E. E. Julian, and K. Y. Wu of Advanced Kinetics under contract to Marshall Space Flight Center (MFS-14217)

Category 02